PIER Energy-Related Environmental Research
Environmental Impacts of Energy Generation, Distribution and Use

# Determining How Fish Detect Fish Screens and Testing Potential Fish Screen Enhancements

**Contract #:** 500-02-004, UC MR-035
**Contractor:** University of California, Davis
**Contract Amount:** $71,418
**Match Funding:** $8,631
**Contractor Project Manager:** Dr. Joseph J. Cech, Jr.
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## The Issue

The water diversions needed for hydroelectric plants, agriculture, and residential water supply can be lethal to fish—including endangered and threatened species—that become entrained in their influent current. Screens are commonly situated in front of water diversions to prevent fish from being displaced from their habitat, but the protective screens themselves can be fatal if fish contact them severely or repeatedly.

This project sought to determine the sensory stimuli that fish use to recognize the presence and threat of fish screens, and to suggest new screen modifications to improve fish passage.

## Project Description

The project used captive-reared, juvenile steelhead trout—a threatened species that must pass through habitats with many water diversions. To determine if steelhead rely primarily on vision, mechanoreception (vibration detection via the fish's lateral line system), or a combination of these senses to recognize and avoid fish screens, screen avoidance experiments were conducted in a custom-built, flume-style swim chamber (Figure 1), where individual steelhead were viewed and video-recorded as they swam in front of wedge-wire fish screens. To determine the contribution of vision to screen avoidance, fish were tested in both light and dark conditions. To determine the contribution of the lateral line system, the antibiotic streptomycin was administered to temporarily block mechanoreception and allow observation of otherwise natural behavior. Treated fish were compared to control (untreated) fish to determine the role of lateral line mechanoreception in screen avoidance.

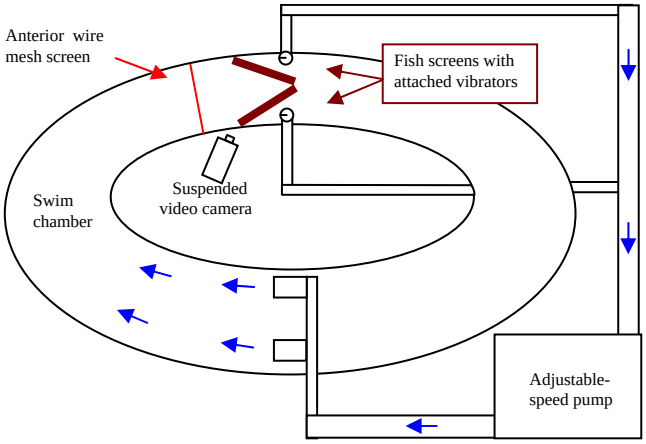


**Figure 1. Swim chamber design**

Vibration was investigated as a deterrent option. Swim trials were run with and without vibrators attached to the middle of the fish screens, just above water level, vibrating at 45 hertz.

The effect of streptomycin on the lateral line system was examined by microscopy as well as by swim trials. Various doses of the antibiotic (ranging from 0.01 g/L to 1.00 g/L) were administered to juvenile steelhead, which were then sacrificed and examined under a scanning electron microscope (SEM).

## PIER Program Objectives and Anticipated Benefits for California

This project offers numerous benefits and meets the following PIER program objective:

- **Providing environmentally sound energy.** California's demand for water and electricity is expected to increase in the near future, increasing need for water diversions and the concomitant threat of entrainment-related losses for aquatic animals. The equipment and results from this study will be used in ongoing PIER-supported research on improved fish screen designs to minimize the impact of water diversions on California's aquatic populations.

## Results

Fish contacted the screen during all treatments. A three-way analysis of variance (ANOVA) analyzing the effects of light level, streptomycin exposure, and screen vibrations found no significant differences between any of the treatments ($P > 0.05$). There was much individual variation in the swimming performance trials of all treatments, most noticeably in the control group. Some steelhead chose not to swim and contacted the screen frequently or impinged on it, while others swam at the front of the chamber and never approached the screen. The individual variation was greater than the variation caused by the treatments, adding to the lack of statistical significance in the findings.

Nonetheless, as can be seen in Figure 2, swimming performance was generally better in the light than in the dark, and without streptomycin, indicating that steelhead use both vision and mechanoreception to avoid screen contact. Vision appears to predominate in this species.

Yet the effect of streptomycin on the steelhead lateral line system—and hence, of mechanoreception on screen avoidance—is not clear. The SEM images showed no indication that the steelhead neuromast (lateral line) cells were damaged, even at 10 times the dose that has been shown to affect trout entrainment in past studies.[1] An electrophysiological study monitoring neural responses in the lateral line system of treated trout (compared to a control group) would be needed to precisely determine the antibiotic's effect.

The report posits various hypotheses for the findings (regeneration rate of neuromast hair cells; nitrogenous waste inactivating streptomycin; behavior differences between captive and wild fish), indicating directions for future study. Through a grant from the WISER Program at Moss Landing Marine Laboratories, supported by PIER, the researchers will continue this investigation with a special focus on increasing the stimuli generated by fish screens: e.g., different frequencies and amplitudes, randomized bursts, and strobe lights.

[1] Montgomery, Carton, et al. 2000. Sensory processing of water currents by fishes. *Philosophical Transactions of the Royal Society of London B* 355:1325–1327.

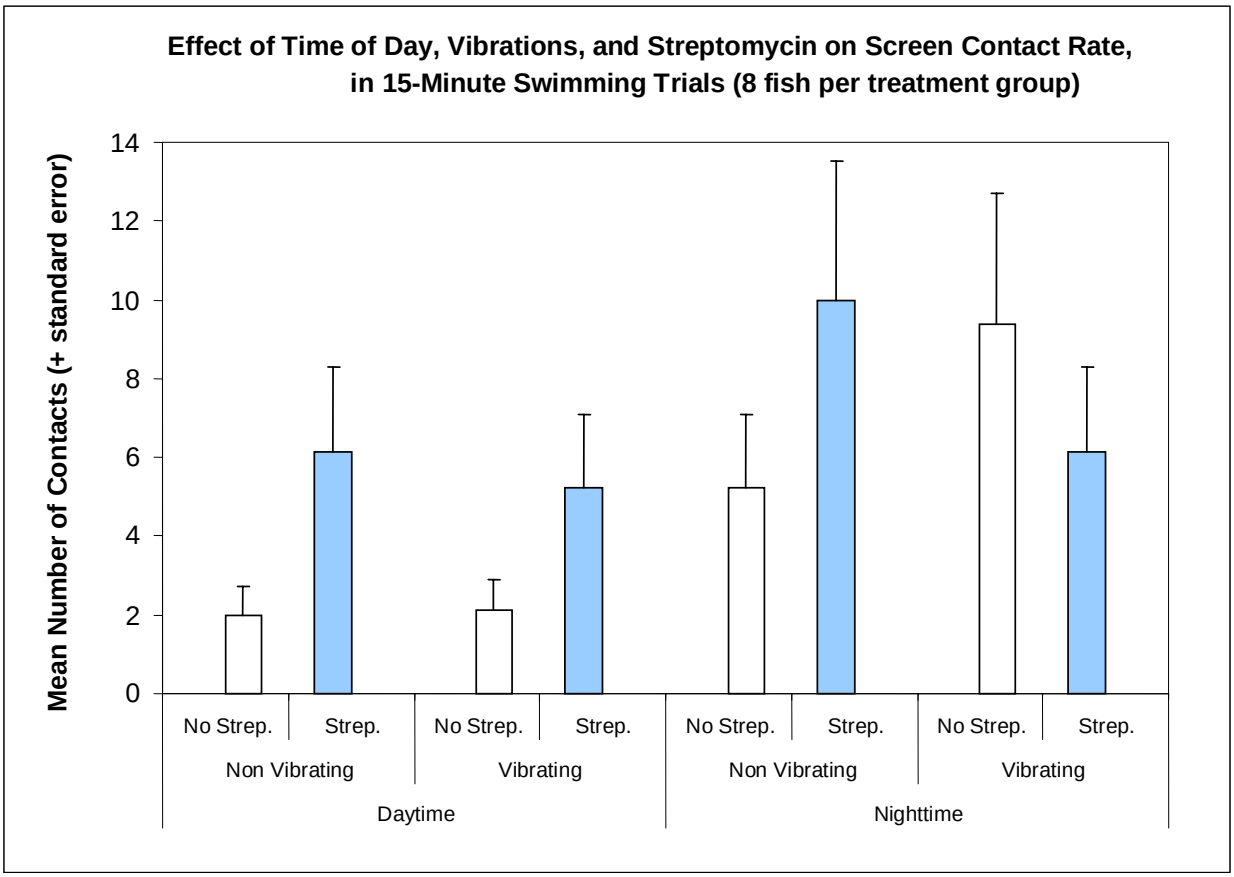


**Figure 2. Effect of time of day, vibration, and streptomycin on screen contact rate, in 15-minute swimming trials (n = 8 per treatment; total of 64 individuals tested)**

## Final Report

The final report for this project, which was funded by PIER's Environmental Exploratory Grant Program, is available at www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2006-117.

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